Catheter Spray of Lidocaine: a Randomized Study of Topical Anesthesia for Flexible Bronchoscopy

Motoko Tachihara; Takashi Ishida; Naoko Fukuhara; Yayoi Inokoshi; Atsuro Fukuhara; Kazue Saito; Taeko Ishii; Kenya Kanazawa; Yutaka Katsuura; Mitsuru Munakata

ABSTRACT — Background. Topical anesthesia is recommended for patients undergoing bronchoscopy. The spray catheter is a device to administer lidocaine in the airway. We performed a prospective, randomized trial to evaluate optimal lidocaine delivery using the spray catheter. Methods. We randomized 88 patients undergoing bronchoscopy without sedation into three groups (catheter A, B, and syringe C, with 23, 34 and 31 patients, respectively). Catheter A patients received two kinds of pre-bronchoscopic lidocaine administration, followed by lidocaine with the spray catheter. Catheter B patients received lidocaine with one pre-bronchoscopic anesthesia, followed by the catheter anesthesia. Syringe C patients received conventional syringe injection after two pre-bronchoscopic anesthesia. Major outcome measures included the frequency of cough, dose and serum concentration of lidocaine, changes in vital signs, and assessment of patient suffering. Results. The lidocaine dose during bronchoscopy in the syringe C group was 312.0 ± 76.0 mg (mean ± SD), which was significantly higher than that in the catheter A (48.0 ± 6.0 mg) and B (50.0 ± 12.0 mg, p < 0.01) groups. Serum lidocaine concentration in catheter A (1.1 ± 0.3 mg/l) and B (1.0 ± 0.1 mg/l) groups was significantly lower than that in the syringe C group (2.2 ± 1.2 mg/l, p < 0.01). There were no statistically significant differences between the three groups in terms of coughing episodes, hemodynamic changes and discomfort questionnaire scores. Conclusion. Safe and efficacious topical anesthesia for awake bronchoscopy can be achieved by catheter spray, with a low dosage and plasma concentration of lidocaine.

KEYWORDS — Catheter spray, Lidocaine, Topical anesthesia, Bronchoscopy

INTRODUCTION

Topical anesthesia of the respiratory tracts is necessary for adequate flexible bronchoscopy. It is achieved in several ways, including administration of anesthetic agents by nebulizer, aerosol spray with Jackson’s laryngotracheal sprayer, or direct injection through the bronchoscope working channel with a syringe. Lidocaine has a better safety profile and efficacy and is, therefore, most commonly used for topical anesthesia. Although usually safe, dose-related cardiovascular and neurologic toxicity are known to occur. Although the total dose of lidocaine used before and during bronchoscopy should be carefully tracked, approximating the actual amount of lidocaine absorbed is not possible because of suctioning during the procedure. Furthermore, there is no consensus on optimal lidocaine administration methods. For example, giving nebulized lidocaine prior to bronchoscopy is common, but its use is controversial.

The spray catheter (Olympus, PW-6C-1, Tokyo, Japan) is a novel device that is introduced via the working channel of a conventional bronchoscope to administer lidocaine in the airway in the form of an aerosol (Figure 1). Lee et al. demonstrated a reduction in the number of cough episodes using this spray catheter.
during curvilinear probe endobronchial ultrasound bronchoscopy (CP-EBUS) in sedated patients. However, so far there has been no prospective study comparing the efficacy of this spray catheter device with other administration methods for awake bronchoscopy, with an eye on plasma lidocaine concentration.

In this study, we performed a prospective, randomized trial to evaluate the optimal lidocaine delivery method for anesthetizing the airway by comparing three techniques using the spray catheter.

**MATERIALS AND METHODS**

**Patients**

This study was approved by the local institutional ethical committee. After obtaining written informed consent, 88 consecutive adult patients undergoing diagnostic flexible bronchoscopy without sedation from February 2010 to September 2010 at Fukushima Medical University Hospital were enrolled.

**Study design**

Enrolled patients were prospectively randomized into three groups using a randomized block design, based on their lesion location (upper, middle, or lower lobe) and the bronchoscopist’s skill, to ensure that these factors were balanced in the study groups.

We used 2% lidocaine for anesthesia in all three groups. In the catheter A group, patients received 5 ml (100 mg) each of a lidocaine aerosol with both ultrasonic nebulizer and Jackson’s laryngotracheal sprayer, followed by lidocaine aerosol with the spray catheter during bronchoscopy. In the catheter B group, patients received 5 ml of a lidocaine aerosol with only the Jackson’s spray, followed by lidocaine aerosol with the spray catheter. In the syringe C group, patients received 5 ml each of the lidocaine aerosol with both ultrasonic nebulizer and Jackson’s sprayer, followed by direct instillation through the bronchoscope with a syringe (Figure 2). The spray catheter groups had the device inserted through the bronchoscope working channel, and 1 ml of lidocaine were pushed through the spray catheter using a 5-ml syringe, followed by a flush of air with an empty 50 ml syringe. In the syringe C group, lidocaine was delivered via a 5 ml syringe containing 2 ml of solution and 3 ml of air in the conventional way.

Prior to bronchoscopy, patients received hydroxyzine hydrochloride by intramuscular injection. In all the groups, bronchoscopy was performed orally without any sedation. Lidocaine was administered in the trachea, carina, both main stem bronchi and lobular bronchi in all groups. After topical anesthesia, we performed airway observation. Supplemental lidocaine was administered according to the state of the cough reflex, as judged by the bronchoscopist, and the total amount of lidocaine used for each patient was recorded. Venous blood samples were collected for measurement of serum lidocaine concentrations at 50 minutes after the commencement of anesthesia, and pulse oximetry and electrocardiogram were monitored continuously during...

**Figure 1.** Spray catheter. (Left) The spray catheter introduced via the working channel of a bronchoscope. (Right) Administration of lidocaine in the airway as an aerosol.
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Assessed for eligibility (n=88) → Excluded (n=0)
Randomized (n=88)

Catheter A group (n=23)  
Catheter B group (n=34)  
Syringe C group (n=31)  

<table>
<thead>
<tr>
<th>Pre-BF*</th>
<th>Ultrasonic nebulizer</th>
<th>Jackson’s sprayer</th>
<th>During BF</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>○</td>
<td>○</td>
<td>Spray catheter</td>
</tr>
<tr>
<td>B</td>
<td>○</td>
<td>○</td>
<td>Spray catheter</td>
</tr>
<tr>
<td>C</td>
<td>○</td>
<td>○</td>
<td>Syringe injection</td>
</tr>
</tbody>
</table>

*BF, bronchoscopy

Figure 2. CONSORT flow diagram and method.

Table 1. Characteristic of Patients

<table>
<thead>
<tr>
<th></th>
<th>Catheter A</th>
<th>Catheter B</th>
<th>Syringe C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>23</td>
<td>34</td>
<td>31</td>
</tr>
<tr>
<td>Sex</td>
<td>male</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Age</td>
<td>67.7 ± 9.0</td>
<td>60.2 ± 16.2</td>
<td>64.5 ± 13.3</td>
</tr>
</tbody>
</table>

the procedure. Automated blood oxygen was monitored every 3 minutes. Supplemental oxygen was administered at 3 l/min via nasal cannulae to all patients. In case of desaturation to 90%, oxygen delivery was increased by 2 l/min.

Outcome measures included the frequency of cough, airway observation time, time to perform anesthesia, lidocaine dose, serum lidocaine concentration, changes in vital signs and assessment of patients' suffering. We evaluated outcome measures before performing some techniques such as brushing, biopsy to avoid the effect according to the kind of examination. Cough rate was counted using a manual counter. Discomfort questionnaire scores ranging from 1 to 3 (1, not unpleasant; 2, unpleasant; and 3, intolerable) were used to assess patients' suffering during bronchoscopy. Adverse events were also recorded.

Data analysis
Analysis was performed using software (Statistical Package for Social Sciences, version 16 for Windows; SPSS). The Kruskal-Wallis test was used to calculate the level of significance in the three groups. All reported p-values are two-sided, and statistical significance was assigned at the 5% level. Results are given as mean ± SD.

RESULTS
A total of 88 consecutive patients were recruited into the study: 23 were randomized to the catheter A group, 34 to the catheter B group, and 31 to the syringe C group. Patient characteristics are presented in Table 1. All examinations could be completed as planned. Age and sex distributions were similar in all three groups.

Outcome measures are shown in Table 2. Total examination time was similar in the three groups. In the catheter groups, about 3 minutes were needed to anesthetize the bronchi. There were no statistically significant differences among the three groups in terms of coughing episodes (p = 0.28) and discomfort questionnaire scores (p = 0.94), respectively.

The total lidocaine dose required in the syringe C group was 522.4 ± 74.8 mg (mean ± SD), which was significantly higher than that in the catheter A (275.0 ± 51.4 mg) and B (185.4 ± 47.4 mg) groups (p < 0.01). Lidocaine dose during bronchoscopy in the syringe C group was 312.0 ± 76.0 mg (mean ± SD), which was significantly higher than that in the catheter A (280 ± 60.0 mg) and B (50.0 ± 120.0 mg) groups (p < 0.01).
Table 2. Outcomes Parameters in Randomized Groups

<table>
<thead>
<tr>
<th></th>
<th>Catheter A</th>
<th>Catheter B</th>
<th>Syringe C</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required to spray (min)</td>
<td>3.3 ± 1.0</td>
<td>3.4 ± 1.1</td>
<td></td>
<td>0.09</td>
</tr>
<tr>
<td>Local anesthesia + Observation time (min)</td>
<td>7.5 ± 1.4</td>
<td>8.7 ± 2.0</td>
<td>7.1 ± 1.5</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cough counts</td>
<td>30.0 ± 25.2</td>
<td>44.7 ± 47.4</td>
<td>28.0 ± 30.0</td>
<td>0.28</td>
</tr>
<tr>
<td>Lidocaine dose during BF* (mg)</td>
<td>48.0 ± 6.0</td>
<td>50.0 ± 12.0</td>
<td>3120 ± 76.0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Supplemental lidocaine dose during BF (mg)</td>
<td>30.0 ± 42.0</td>
<td>32.0 ± 42.0</td>
<td>120.0 ± 22.0</td>
<td>0.14</td>
</tr>
<tr>
<td>Total lidocaine dose (mg)</td>
<td>275.0 ± 51.4</td>
<td>185.4 ± 47.4</td>
<td>522.4 ± 74.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Lidocaine concentration (mg/l)</td>
<td>1.1 ± 0.3</td>
<td>1.0 ± 0.1</td>
<td>2.2 ± 1.2</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Variation of blood pressure (mmHg)</td>
<td>22.7 ± 21.1</td>
<td>26.2 ± 30.6</td>
<td>21.1 ± 18.4</td>
<td>0.87</td>
</tr>
<tr>
<td>Variation of heart rate (/min)</td>
<td>20.7 ± 17.0</td>
<td>19.3 ± 18.5</td>
<td>20.1 ± 15.5</td>
<td>0.91</td>
</tr>
<tr>
<td>Decline of SpO2* (%)</td>
<td>1.6 ± 2.5</td>
<td>1.9 ± 2.9</td>
<td>21 ± 3.1</td>
<td>0.62</td>
</tr>
<tr>
<td>Questionnaire score 1</td>
<td>10</td>
<td>7</td>
<td>7</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>

BF: bronchoscopy; SpO2: percutaneous oxygen saturation.

The mean supplemental dose of lidocaine was 30.0 ± 42.0 mg in the catheter A group, 32.0 ± 42.0 mg in the catheter B group, and 12.0 ± 22.0 mg in the syringe C group, the differences being statistically not significant (p = 0.14). Serum lidocaine concentration in the catheter A (1.1 ± 0.3 mg/l) and B (1.0 ± 0.1 mg/l) groups was significantly lower than that in the syringe C group (2.2 ± 1.2 mg/l, p < 0.01). One patient in the syringe C group had a serum lidocaine concentration of 6.6 mg/l.

Hemodynamic variation profiles during bronchoscopy and questionnaire scores were similar between the three groups. There were no complications associated with lidocaine administration. Anesthesia was safely administered by the spray catheter.

DISCUSSION

Patients' tolerance of flexible bronchoscopy, especially in the absence of sedation, depends on the efficacy of topical anesthesia. However, there are no recommendations about specific administration methods. Lidocaine is the most commonly used local anesthetic agent, but precautions are necessary to prevent excessive administration to avoid lidocaine-related adverse events. Major adverse effects become more likely if the total topical lidocaine dose exceeds 7 mg/kg or plasma levels exceed 5 mg/l. Lidocaine is rapidly absorbed into the systemic circulation with peak plasma concentrations reported within 20-50 min from the beginning of local anesthesia, these values being influenced by the study design. In the present study, we evaluated three different methods of administration of topical anesthesia using the spray catheter for flexible bronchoscopy. We examined the utility of the spray catheter and the necessity of administering ultrasonic nebulized lidocaine prior to bronchoscopy.

To date, there is a consensus statement on the use of lidocaine during flexible bronchoscopy in adult patients. However, there is no decision about the density of lidocaine to be used. A previous report evaluated atomized lidocaine for airway anesthesia, comparing 2% and 4% lidocaine. Compared with 4% lidocaine, the 2% dose provided acceptable efficacy with lower plasma lidocaine levels. We referred to this report and used 2% lidocaine in our study.

The efficacy and safety of local anesthetic aerosol administration via a spray catheter in the airway have been previously reported. In the present study, we evaluated the efficacy and safety of the spray device (Olympus, PW-6C-1) compared to the conventional method. The total lidocaine dose and serum lidocaine concentrations in the catheter A, B groups were significantly lower than that in the syringe C group. In the syringe C group, mean total lidocaine dose was 522.4 mg. It has been suggested that the total dose of lidocaine should be limited to 300-400 mg. Fortunately, our patients did not show any adverse effects, but we should refrain the dose of lidocaine as long as possible. One patient in the syringe C group had a serum lidocaine concentration of 6.6 mg/l over safety margin, although the total amount administered was 348 mg. A correlation has been reported between plasma lidocaine levels and the total dose of local anesthetic administr-
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tered during bronchoscopy. This, however, varied from individual to individual. As long as we cannot monitor lidocaine concentration, we should attempt to use the minimum required dosage. There were no differences in the number of coughs and discomfort questionnaire scores among the three groups. We could demonstrate the utility of spray catheter in refraining the number of cough and discomfort with less lidocaine usage.

In addition, giving nebulized lidocaine prior to bronchoscopy is common, but its use is controversial. Some studies demonstrated patients’ preference for nebulized lidocaine over a spray. However, more recent placebo-controlled trials on flexible bronchoscopy under sedation showed no difference in cough and discomfort scores between the two arms. In the present study, examination time and the number of coughs were a little bit more in the group without prebronchoscopic ultrasonic nebulization (catheter B) although the differences were not statistically significant. There is a possibility that ultrasonic nebulization might be needed for bronchoscopy without sedation, but in the present study this was unclear because the lidocaine dose used between three arms prior to bronchoscopy is different.

One possible limitation of the spray catheter is that the external diameter of the catheter is 1.9 mm. When a bronchoscope with a 2.0 mm working channel is used, it is difficult to effectively aspirate respiratory secretions when the spray catheter is inserted.

In conclusion, we demonstrated the safety and efficacy of topical anesthesia via a catheter spray for flexible bronchoscopy without sedation, successfully achieving a lower dosage and hence, plasma concentration of lidocaine.

Acknowledgement: The authors thank the endoscopy staff (Yoshinori Tanino, Junpei Saito, Hiroshi Yokouchi, Suguru Sato, Kengo Oshima, Satoko Sekine, Takefumi Nikaido, Hiroyuki Minemura, Manabu Uematsu, and Kenichi Misa) for their excellent collaboration.

REFERENCES